The insulin left unencapsulated in the liposomes was collected from the column and the amount was determined using a radio-immuno-assay (RIA) Based on this number, the entrapment efficiency of the insulin was determined.

In vivo Insulin Delivery

Balb/C mice of female sex were fasted for 12 hours before experiment. Each mouse was gavaged 200 μL of each preparation as described in Table 9.3. Food was restored immediately after administration. Blood samples for glucose determination was drawn from mouse tail vein under methoxyflurane anesthesia. Samples were drawn right before the administration (O hour), as well as at 1, 2, 3 and 3.5 hours post administration of each preparation. Blood glucose level was measured using a One Touch® Profile Diabetes Tracking System (Lifescan, Milpitas, Calif.) with One Touch® Test strips, by applying blood to form a round drop which completely covered the test spot on the test strip. Readings (in mg/dL) were obtained from the meter indicating the blood glucose level detected.

11.2. RESULTS

The liposomes were characterized as described infra. The amount of insulin encapsulated in the liposomes was determined using the RIA assay (performed by Linco Research, St. Charles, Mo.) to be about 5 IU/mL of liposome suspension.

Blood glucose level at zero hour was taken at 100 percent. Blood glucose levels after the oral administration were normalized by the level at zero hour, and the results were plotted in FIG. **9**. It can be seen that when administered in solution, insulin did not result in any significant change in mouse blood glucose levels (FIG. **9**). This was due to the degradation of the unprotected peptide in the gastrointestinal tract by the digestive enzymes. When insulin was encapsulated in unpolymerized liposomes, no drop in blood glucose level was observed (FIG. **9**), suggesting that the unpolymerized liposomes were not able to protect the encapsulated insulin from degradation. This is consistent with the fact that unpolymerized liposomes are not stable in the gastrointestinal tract, where they are dissolved by the biological detergents. The dissolution results in the exposure of liposomal contents and therefore the loss of liposome protective functions. PBS was also administered to the mice as an experimental control. No significant-decrease was observed in the blood glucose levels (data not shown).

When insulin was encapsulated into the liposomes and the liposomes were subsequently stabilized through polymerization, a significant decrease in blood glucose level (to ~70% of original) was observed at two hours post administration (FIG. **9**). Furthermore, when the polymerized liposomes were surface-modified with UEA I molecules, which were shown to target the liposomes to Peyer's patches and give improved oral delivery efficiency, the blood glucose dropped ~40% compared to the original level at 3 hours post administration (FIG. **9**). In both cases, no significant change in the glucose level was observed at one hour after the administration. This lag time is due to the gastric and intestinal transit time of these liposomes.

The results of these studies demonstrate the efficacy of lectin modified polymerized liposomes to provide protection for diphtheria toxoid as well as insulin. Both peptides retained their biological activity after the encapsulation and polymerization process. When orally administered to mice, both peptides displayed their desired biological responses. Lectin modified polymerized liposome encapsulated diphtheria toxoid was shown to induce both primary and secondary immune responses in mice and lectin modified polymerized liposome encapsulated insulin was shown to reduce blood glucose levels in mice. These results demonstrate that polymerized liposomes of the invention can be used as delivery systems.

The present invention is not to be limited in scope by the specific embodiments described herein. Indeed, various modifications of the invention in addition to those described herein will become apparent to those skilled in the art from the foregoing description and accompanying figures. Such modifications are intended to fall within the scope of the appended claims.

Various publications are cited herein, the disclosures of which are incorporated by reference in their entireties.

We claim:

1. Polymerized liposomes comprising a phospholipid bilayer having covalently bonded phospholipids, an aqueous core and a lectin wherein the lectin is Ulex Europeans Agglutinin I.

2. The liposomes of claim **1** further comprising an antigen, a biologically active molecule or a detectable molecule.

3. The liposome of claim **1** wherein the targeting molecule is modified Ulex Europaeus Agglutinin.

4. The liposomes of claim **2** wherein the biologically active molecule is selected from the group consisting of cells, viruses, vectors, proteins, peptides, nucleic acids, polysaccharides, carbohydrates, lipids, glycoproteins, drugs or combinations thereof.

5. The liposomes of claim **2** wherein the biologically active molecule is an antigen.

6. The liposomes of claim **5** wherein the antigen is influenza hemeagglutinin.

7. The liposomes of claim **5** wherein the antigen is the ospA antigen from Lyme disease bacteria.

8. The liposomes of claim **5** wherein the antigen is a fragment of diphtheria toxin.

9. The liposomes of claim **1** having a degree of crosslinking between 30 and 100 percent.

10. The liposomes of claim **1** comprising phospholipids selected from the group consisting of double bond-containing olefinic and acetylenic phospholipids and phospholipids containing thiol groups.

11. The liposomes of claim **1** having a diameter of between fifteen nm and ten microns.

12. The polymerized liposome of claim **1** wherein said phospholipid is DODPC.

13. The polymerized liposome of claim **12** wherein the polymerized liposome comprises about 85 to 100% DODPC.

14. A method of delivering therapeutic molecules to an animal which comprises administering to said animal polymerized liposomes comprising a phospholipid bilayer having covalently bonded phospholipids; an aqueous core; a lectin wherein the lectin is Ulex Europeans Agglutinin (UEA) therapeutic molecule.

15. The method of claim **14** further comprising at least one targeting molecule selected from the group consisting of glycoproteins, antibodies, antibody fragments, or cell surface receptors and ligands.

16. The method of claim **14** wherein the therapeutic molecule is a detectable compound selected from the group consisting of radiopaque substances, air, magnetic materials, or substances detectable by magnetic resonance imaging.

17. The method of claim **14** wherein the molecules are biologically active substances selected from the group consisting of cells, viruses, vectors, proteins, peptides, nucleic acids, polysaccharides and carbohydrates, lipids, glycoproteins, or combinations thereof, and synthetic